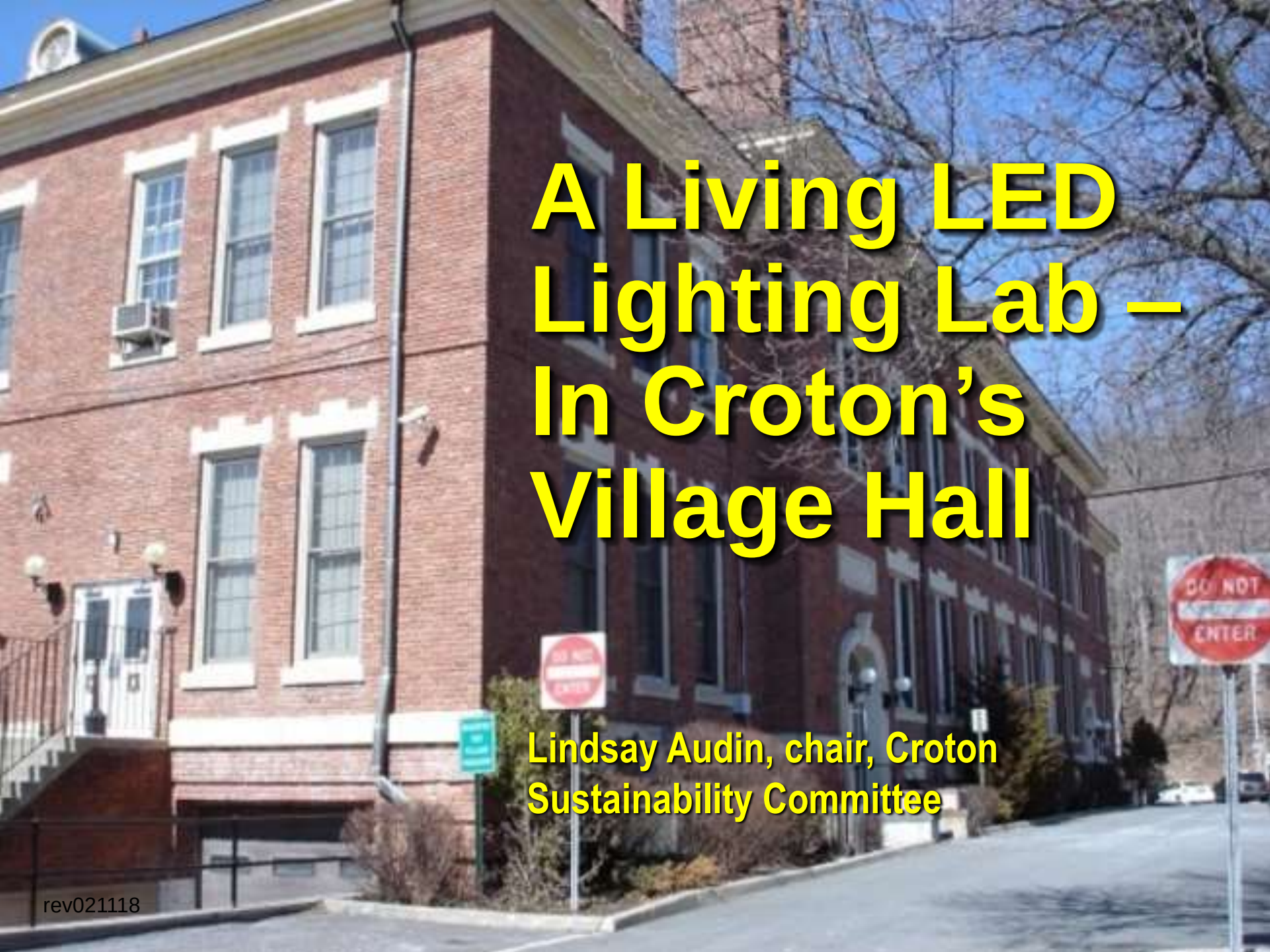


A Living LED Lighting Lab – In Croton's Village Hall

Lindsay Audin, chair, Croton Sustainability Committee

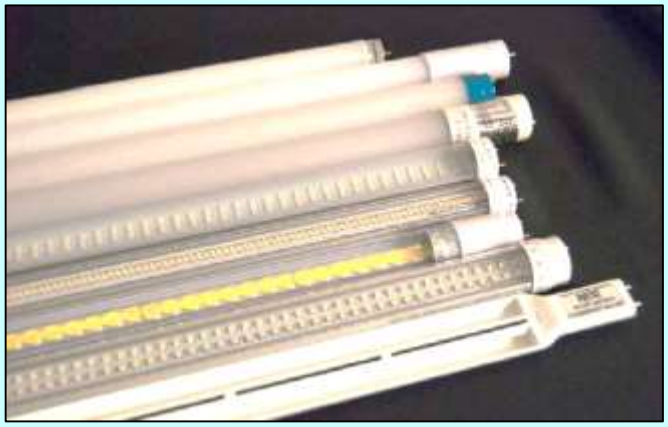
rev021118

Cut Cost & Carbon With LEDs

Converting indoor lighting from fluorescent to LED saves energy, cuts utility bills, and lowers maintenance costs, while reducing a facility's carbon footprint.

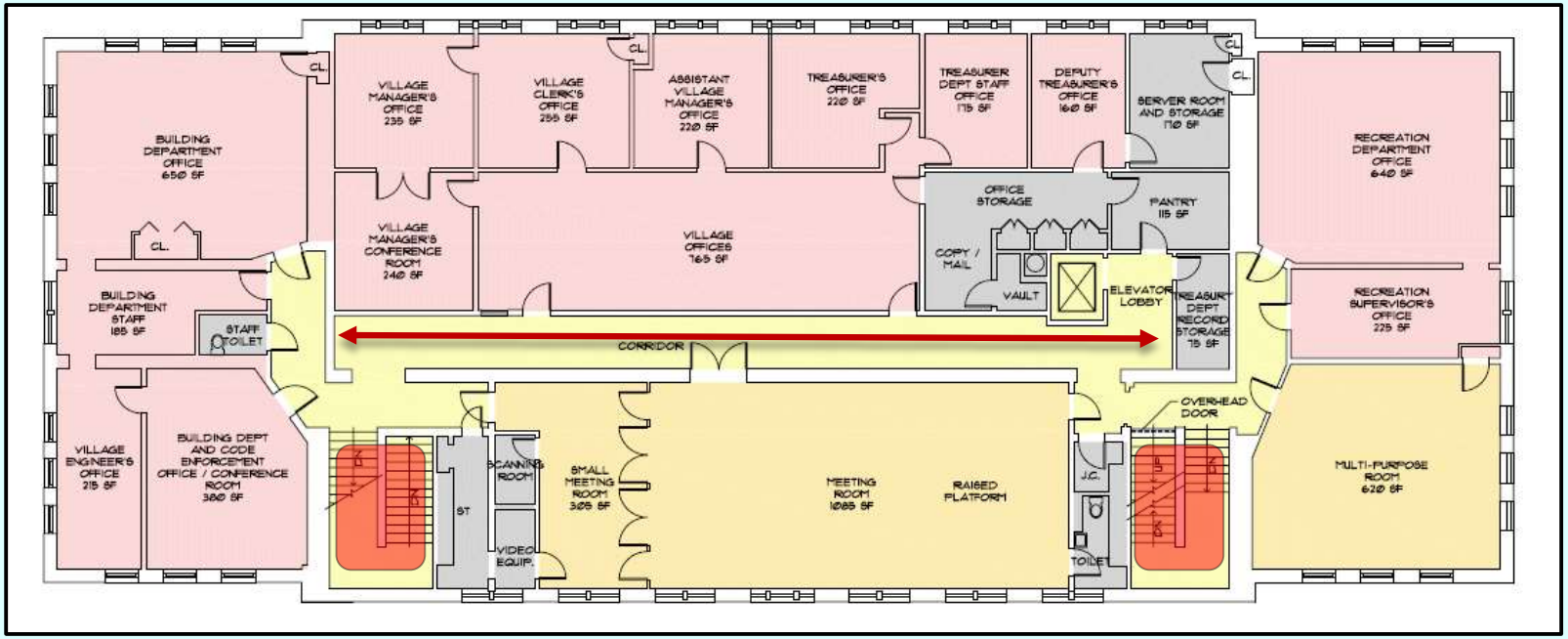
But choosing the best LED option can be a challenge:

- Replace fluorescent lamps with tubular LED (TLED) lamps?
- What about LED retrofit kits?
- Buy <u>new</u> fixtures with built-in LEDs?



Croton's Living LED Lighting Lab

To demonstrate differences among LED choices, Croton retrofitted 10 fixtures in the 2nd floor corridor of its town hall (7 with TLEDs and 3 with retrofit kits). Elsewhere, staff chose a mix of TLEDs and kits. Bi-level fixtures were installed in stairwells, and occ. sensors in the basement.



Re-lighting Croton's Municipal Bldg.

Built in 1909 as a K-12 school, the Kellerhouse Municipal Bldg. was re-purposed into village offices in 1939. In the '90s, T8 lamps & electronic ballasts replaced T12 lamps running on magnetic ballasts. *Converting to LED now brings 21st century lighting to our century-old village hall*.

Each year, this upgrade will:

- cut ~$12,000 off utility bills
- save about 76,000 kWh
- and eliminate 16.3 tons of carbon.

It will take 16 kW of load off the grid,

lower the building's cooling load,

and - due to LED's long life - avoid relamping for 15 to 20 years.

Croton greatly appreciates NYSERDA's funding and support.

Know Your Lighting Lingo

Fixture (a/k/a “luminaire”)
Ballast/driver
Lamp (not “bulb” or “tube”)
T12, T8, T5
Lampholder (a/k/a socket, or “tombstone”)
Retrofit kit (not same as a new fixture)
TLED types: A, B, C, A/B, A/C
Lumens
Foot-candles (F-C) (i.e., lumens/sq.ft.)
Color (CCT) (in ^{o}K)
Color Rendering Index (CRI)
Beam angle/spread
Candela distribution
Flicker % and frequency
L70, PF, THD, E-I-E-I-O…

If any of this is new to you, see pages 2 & 3 of the 8-page brochure for explanations.

The Bottom Line

All 7 types of tubular LED (TLED) lamps we tested yielded similar results. But labor and lamp costs may affect ROI and/or lifecycle value about as much as differences in lumens/watt (i.e., efficacy).

Due to testing & certification by DOE/DLC, differences in other traits (PF, THD, CRI, CCT, L70) are minimal.

Instead, issues such as fixture/ballast/lampholder, beam angle/spread, glare, flicker, dimming, warranty, rebate, and vendor track record may affect choice. To ensure long-term acceptability, take them into account.

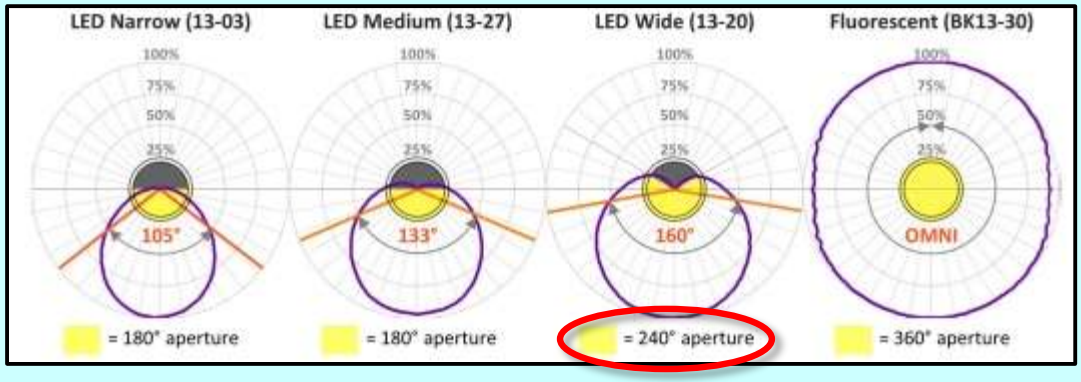
But if you have the $, buy retrofit kits or new fixtures.

How TLEDs Save Energy & $

They produce more lumens/watt than fluorescents, and so need fewer watts to yield the same lumens. They also narrow their light distribution downward while fluorescents emit light around their circumference (see chart below).

Doing so reduces losses due to reflections inside a fixture, so fewer lumens are produced to yield similar task light levels. But that may reduce light levels on walls and partitions, and horizontally between fixtures.

Beam angle and spread ("aperture") quantify that narrowing.



Comparing The Options

The LED retrofit options are aligned so a viewer may see how they differ visually. The 8-page brochure compares them on various criteria, such as:

- equipment cost
- labor time to install
- beam angle/spread
- task light levels

Get copies of the brochure at the Village Mgr.'s office (room 24).

Bi-level LED fixtures with built-in motion sensors are installed in the stairwells. To show other control options, 2 basement rooms have wireless or switch-mounted motion sensors.

Variation in Color & Distribution

While exaggerated by my camera's color sensitivity, note the differences between colors of the walls and wood flooring. Fluorescents were 4100 K, all LEDs are 4000 K, and all CRIs are 80+. But appearance does change a bit.

Also note slightly enhanced shadow pattern on the floor due to narrowed beam spreads.

Once all fixtures in a room are converted, color variations are not noticeable, but other differences may be.

Visual Differences May Be Subtle

Starting with #1, watch for distracting light patterns and “scalloping” on walls.

Look for glare issues (e.g., #1’s bare LEDs, #9 may create PC screen glare).

With a light meter, measure F-C levels below and between fixtures 30” AFF.

With a flicker wheel, discriminator, or meter, find uncorrected flicker in #6.

In #8, “lamps” are actually LED strips covered by half-round frosted diffusers.

Differences in equipment cost and labor time may be more significant issues.

Equipment & Labor Costs May Outweigh Lamp Efficacy

The cheapest TLED we used was ~$8; most expensive was ~$37. That difference alone may outweigh savings from slightly higher lumens/watt (i.e., efficacy).

Quickest installation: 2 min. for Type A. Longest was 30+ minutes for: single-ended Type B, Type C, and one retrofit kit. For those options, time an installation into a fixture while it's on a work bench. If it takes >10 min., repeat it to improve your method. Then see how long it takes to do it that way while on a ladder in a room lit only by work lights. If problematic, consider switching to an easier option.

Review The Options Spreadsheet

Col. A shows some factors we measured or calculated based on our 3-lamp fixtures, each of which had a 3-lamp ballast and unshunted sockets.

Col. B shows data for the unchanged fixture as a control.

Note issues related to:

- Total watts (for 3 lamps)
- Nadir F-C (while fixture is isolated)
- Install time vs. powered ends
- Retail price (~25% off in bulk)
- Impacts of assumed 48K lifetime
- Flicker % (after replacing equpmt.)
- Startup speed

A	B	C	D
Fixture number	0	1	2A
Brand name	control	ThinkLite	Energy Focus
Model No.	std. 32W T8	TL-T8X120-10W-C-41K-G-W-N [low flicker]	Intellitube LEDFLT8-840-413-IT3F
Option Type	N/A	type B	type B
lamp beam angle/spread (degs)	N/A	120/270	120/270
wired ends	double	double	single
install time (either lamps or kit) min:sec	2:00	16:11	30:00
nadir FC	29.5	26.1	27.0
retail matl. cost per lamp or kit	$1.50	$37.00	$16.00
no. of lamps/fixture @ 48K hrs	9	3	3
ballasts @ 48Khrs	1	0	0
total watts	90	42	39
annual energy saving @ $.16/kWh	$0.00	$23.04	$24.48
annual tons CO2 saving @ .5 ton/MWh	0.000	0.072	0.077
ballast discriminator G=green R=red	G	G	G
flicker %	2	2	0
flicker freq. range Hz	13K-17K	610-1.3K	0
startup speed	instant	slight delay	instant

Getting Started At Your Site

Prioritize your goal(s): Best lifecycle savings? Cheapest equipment? Quickest installation? Adjust light levels? Reduce GHG emissions? Upgrade fixture appearance? Improve light distribution? Enable dimming?

Characterize existing equipment: Ballast type(s)? Socket shunting? Fixture type(s)?

Labor types and costs: Which options (e.g., TLED type B or retrofit kit) may require an electrician? Will outside union personnel be needed? Can in-house staff read instructions and wiring diagrams in English?

Check Ballast Compatibility

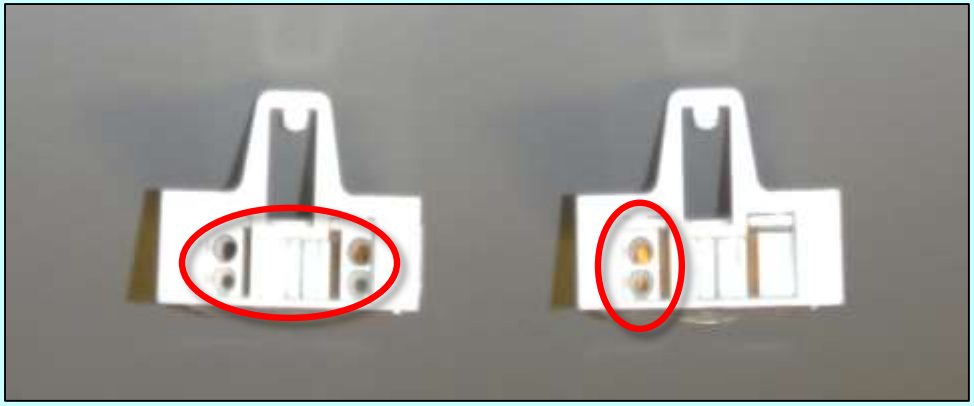
Fluorescent ballasts may be:

- Electronic instant start
- Electronic rapid start (dimmable?)
- Electronic programmed start
- Electronic with a backup battery
- Magnetic rapid start

While type A TLEDs work with many (but not all) types of electronic ballasts, at this time only one type A (ELB Electronics) also works with magnetic ballasts. TLED types B and C (and retrofit kits) bypass ballasts, eliminating this issue. ELB says its TLEDs work with any ballast, and offers a reward if one of them doesn't. Before buying type A TLEDs, check ballast compatibility!

Socket Shunting May Limit Options

Fluorescent lampholders (sockets) are either unshunted (requiring power to both contacts, see left socket) or shunted (contacts are shorted together, see right socket). Some TLEDs work with only one type, while others work with both. Before buying any TLEDs, check your sockets and Type B & C TLED wiring diagrams!



Retrofit kits bypass sockets and avoid this issue.

Interactions With Fixtures

5 basic types of linear fluorescents:

- Troffer (recessed, surface mounted)
- Wrap-around / Cloud (surface, pendant)
- Indirect (e.g., cove, valance, pendant)
- Direct-Indirect (recessed, pendant)
- Industrial (surface, pendant)

Low beam angle/spread may narrow light distribution, creating or worsening a “cave” effect. TLEDs work better in enclosed fixtures due to immunity from temperature effects. Direct-indirect fixtures may need “dual shine” TLEDs that emit light both up and down.

Avoiding Non-Visible Flicker

T12 lamps on magnetic ballasts flicker at 120 Hz, which may cause headaches, fatigue, or worse. In 1 out of ~4,000 people, photo-epileptic seizures may result. In some autistic children, it may lead to behavioral problems.

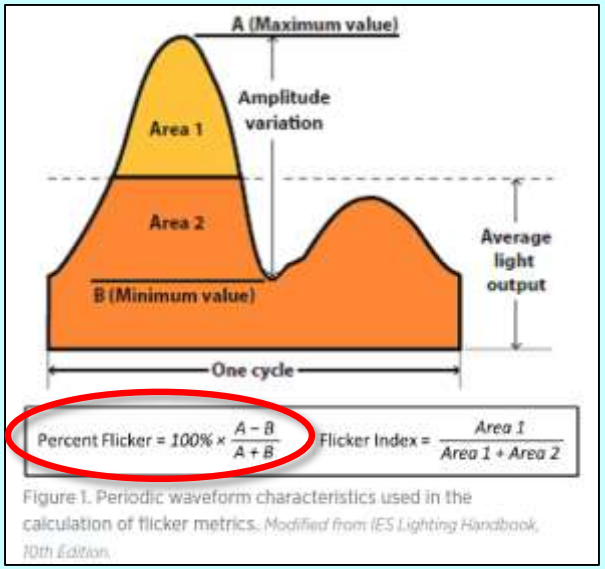


Figure 1. Periodic waveform characteristics used in the calculation of flicker metrics. *Modified from IES Lighting Handbook, 10th Edition.*

Electronic ballasts eliminated that issue. But we found that some LED options (e.g., type B) have similar or higher flicker %. While there's no standard for allowable flicker, IEEE 1789-2015 is fast becoming the spec to use. It limits flicker % based on flicker frequency to avoid problems.

Does LED + Motion Sensing = $?

Lifetimes of fluorescent lamps (especially when powered by instant start ballasts) may be significantly shortened by the extra on-off cycling due to motion sensors. But LED chip life is not shortened by on-off cycles.*

LEDs are better suited for use with sensors, saving even more energy and money.

But think it through: depending on how your electric rate is structured, the extra $ savings may not justify the cost of the sensors. Once lighting wattage has been cut by half (or more), fewer lighting dollars are left to save by adding sensors.

*However, LED driver life may be reduced with much greater on-off cycling.

Test Before You Invest

To be sure you see how a TLED or retrofit kit may affect light distribution, color, etc., convert fixtures in an entire room using the same option, comparing before and after:

- Task F-C (horizontally, typically 30" AFF)
- Wall/partition F-C (especially on light colored surfaces)
- Visual distribution (does space "seem brighter/darker")
- Glare (excessive brightness within the visual field)
- Changes in coloration of furnishings, skin, products

Ask occupants to try it for 2 weeks. If problems persist, adjust as needed (e.g., change lamp, louver, etc.).

Plan For The Future

If existing F-C, distribution, etc. don't need to be changed, leave them as is, but consider future uses of your spaces.

Your facility may wish, for example, to engage in demand response that involves dimming or re-circuiting fixtures. Perimeter spaces with large windows may be ideal for "daylighting" to save energy and cut utility bills.

Work tasks may change: a cafeteria becomes a computer lab needing a lower light level (or indirect lighting), or becomes a conference space requiring an ability to dim its lights.

Choose today's equipment with tomorrow's needs in mind.

Options Chosen By Croton

Croton's fixtures were recessed troffers with deep cell parabolic louvers having a narrow beam spread.

Ballasts were instant start, and sockets were unshunted. After reviewing the options and their economics, staff chose flat panel LED retrofit kits for ~70% of the fixtures and A/B TLED lamps (in A mode) for the other ~30%.

As their ballasts fail, those fixtures will be re-wired to use the same TLED lamps in their B mode.

Doing so saved enough grant money to cover retrofitting many of the fixtures in the DPW's building with a similar mix (with NYSERDA's permission).

Making Sustainability Happen

Croton is famous for its scenic waterfront, rivers, and parks, and we work every day to be a sustainable community. This LED project is another step in that process.

Croton appreciates NYSERDA's funding and support.

PDF copies of these slides and the brochure are available on request. Please email us at info@sustain-croton.org.

Thank you for your time and attention.